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(54) Abstract Title

Modular system and method for processing and injecting oil and gas drill cuttings

(57) An automated, high-speed modular system for processing drill cuttings and then injecting them into a surrounding formation comprises a conveying system, a holding tank 24 and two slurry tanks 16,22, circulating pumps 18,19,28, a high-speed grinding mill 26, a high-pressure injection pump 30, a fragmentation system and a automated system 36 for controlling the operation of the injection pump. The conveying means comprises an in-feed cuttings conveyor 14 and a system shale shaker 20. Cuttings are fed into the first slurry tank 16, mixed with water, and ground into a slurry by the grinding action of pumps 18,19. The slurry is then pumped by either of pumps 18,19 to the system shale shaker 20. The slurry passes through the screens of the shaker into the second slurry tank 22 or to the holding tank 24. Cuttings that don't pass through the shakers screens are ground by a roll mill 26. The automation system 36 has automatic speed control regulation with torque and horsepower limiting features. A line (38, figure 4) connected to the discharge line of the injection pump 30 is routed to the holding tank 24 where it is divided into two nozzles (40, figure 4) which are directed onto heavy plates (42, figure 4). The line (38, figure 4) may be charged at high pressure and the discharge flow directed into the holding tank 24 via the nozzles. Any entrained cuttings strike the heavy plates at high velocity causing fragmentation.

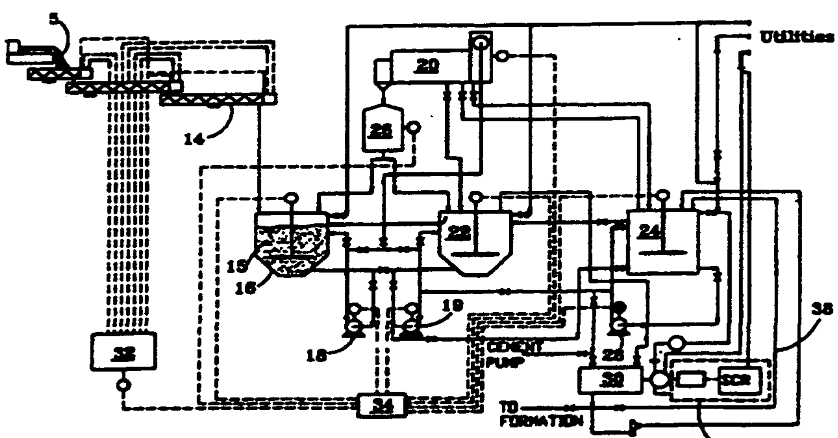

FIG. 3

At least one drawing originally filed was informal and the print reproduced here is taken from a later filed formal copy.

This print takes account of replacement documents submitted after the date of filing to enable the application to comply with the formal requirements of the Patents Rules 1995

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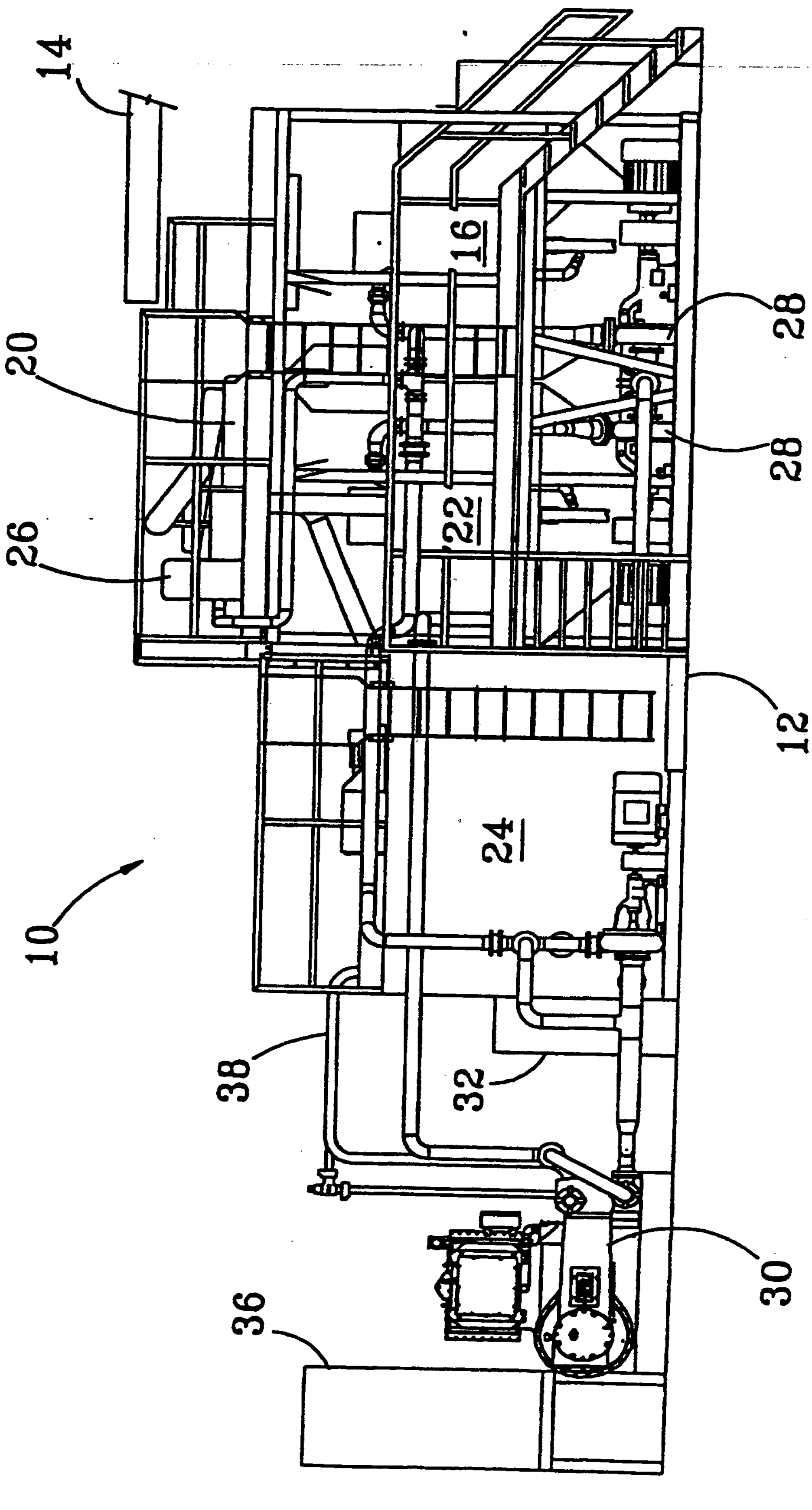

FIG. 1

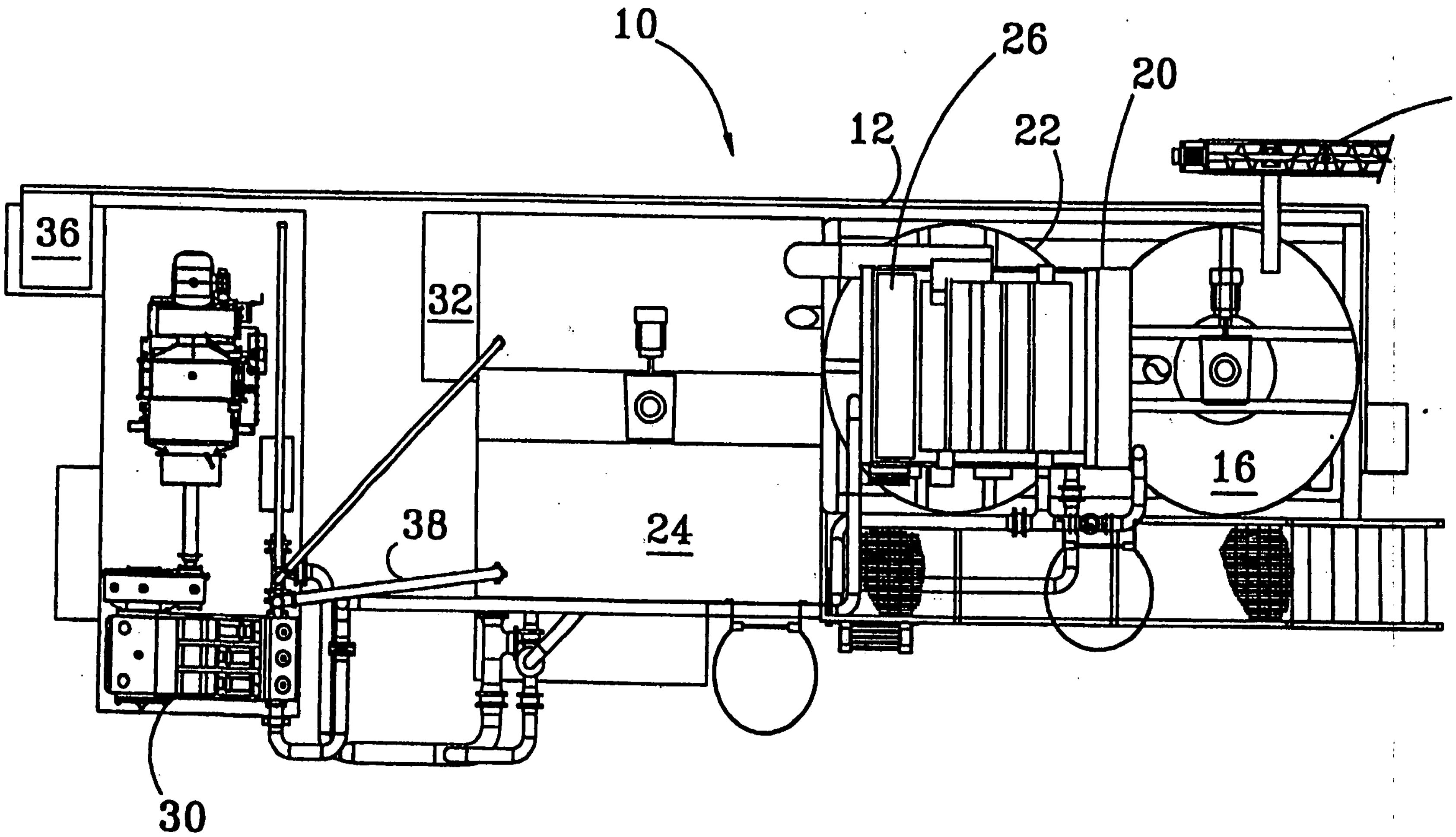

FIG. 2

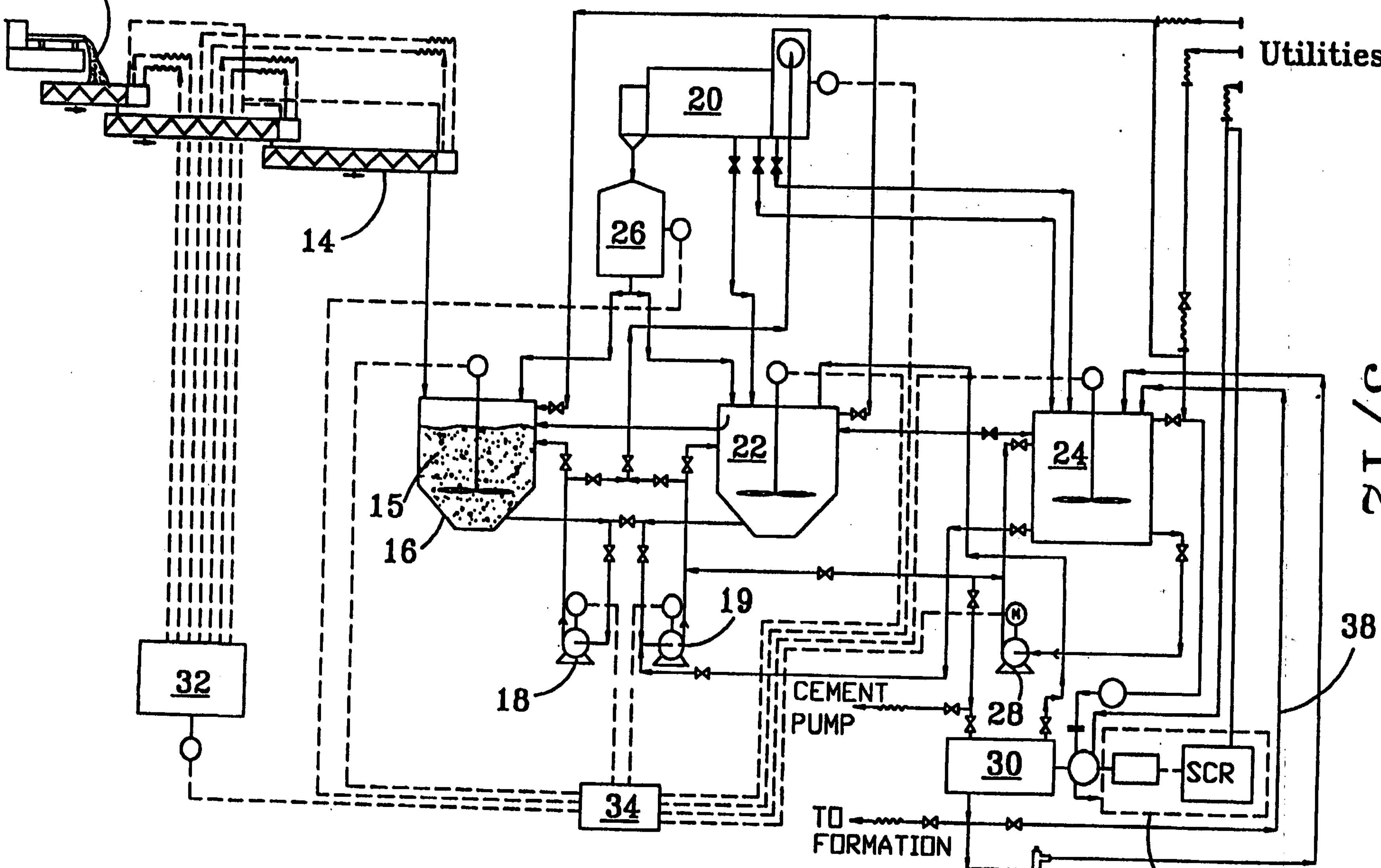
Utilities
5
14
20
26
15
16
22
24
18
19
28
30
32
34
36
38
SCR
CEMENT PUMP
TO FORMATION

FIG. 3

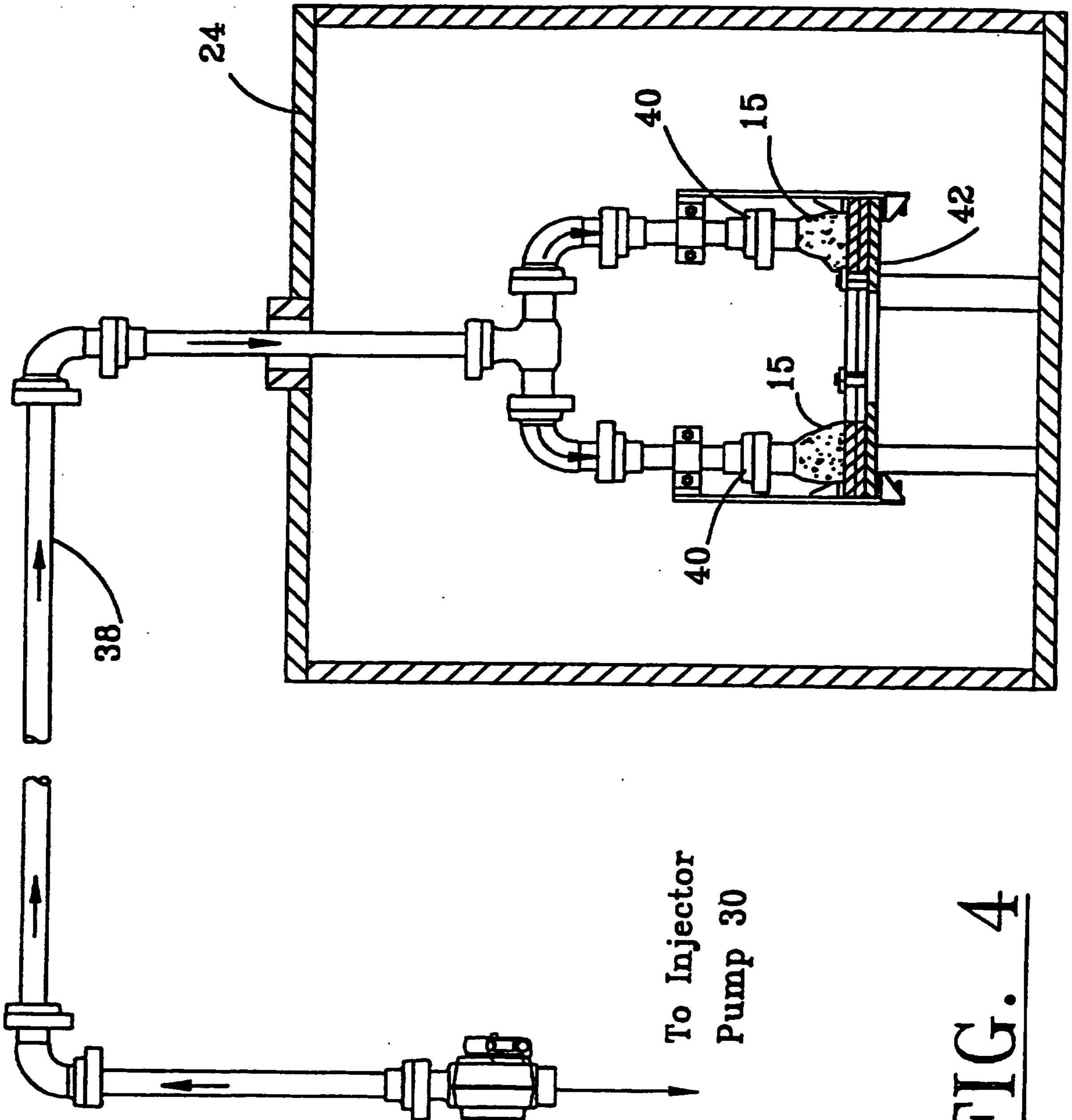

FIG. 4

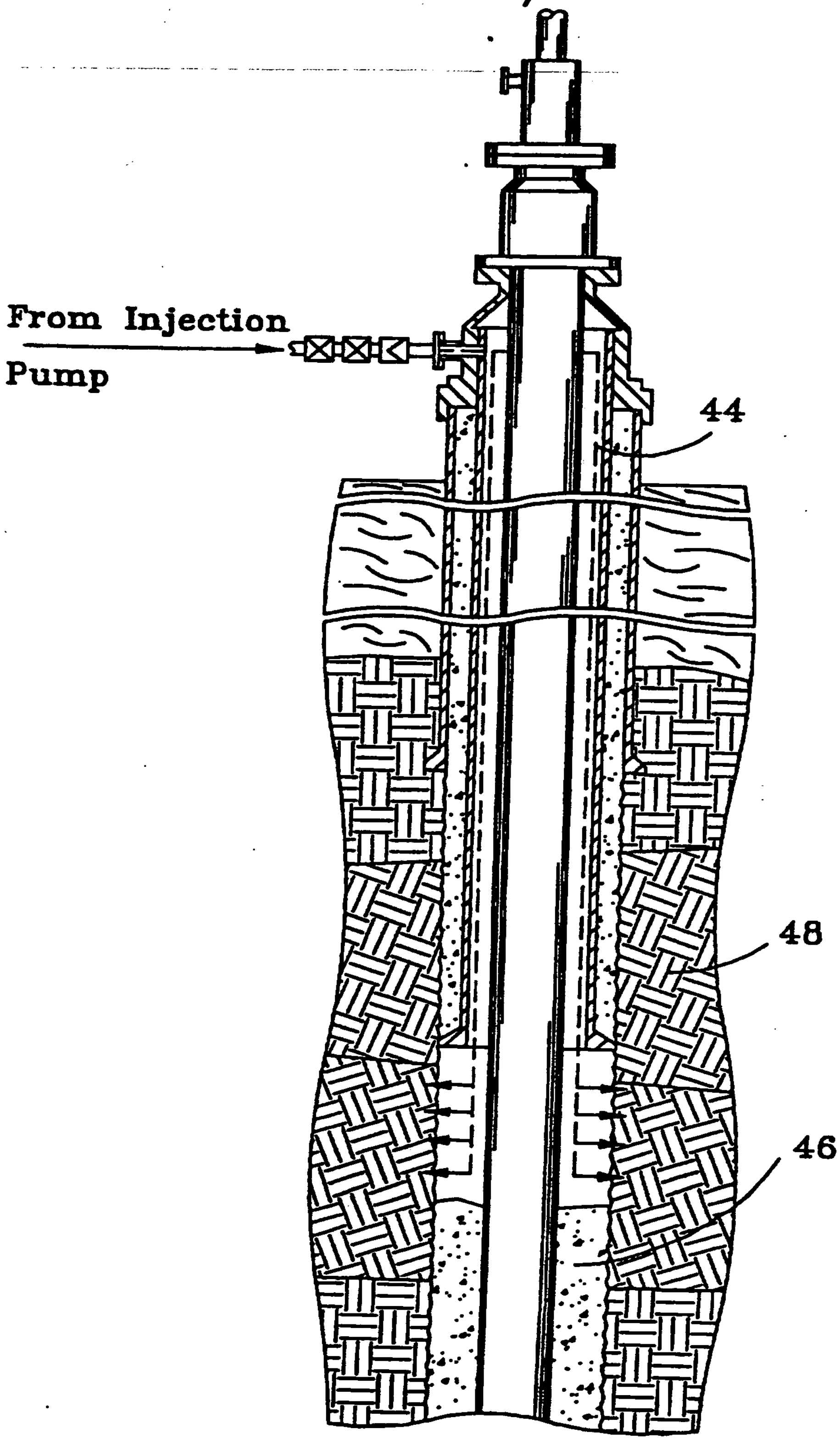

FIG. 5

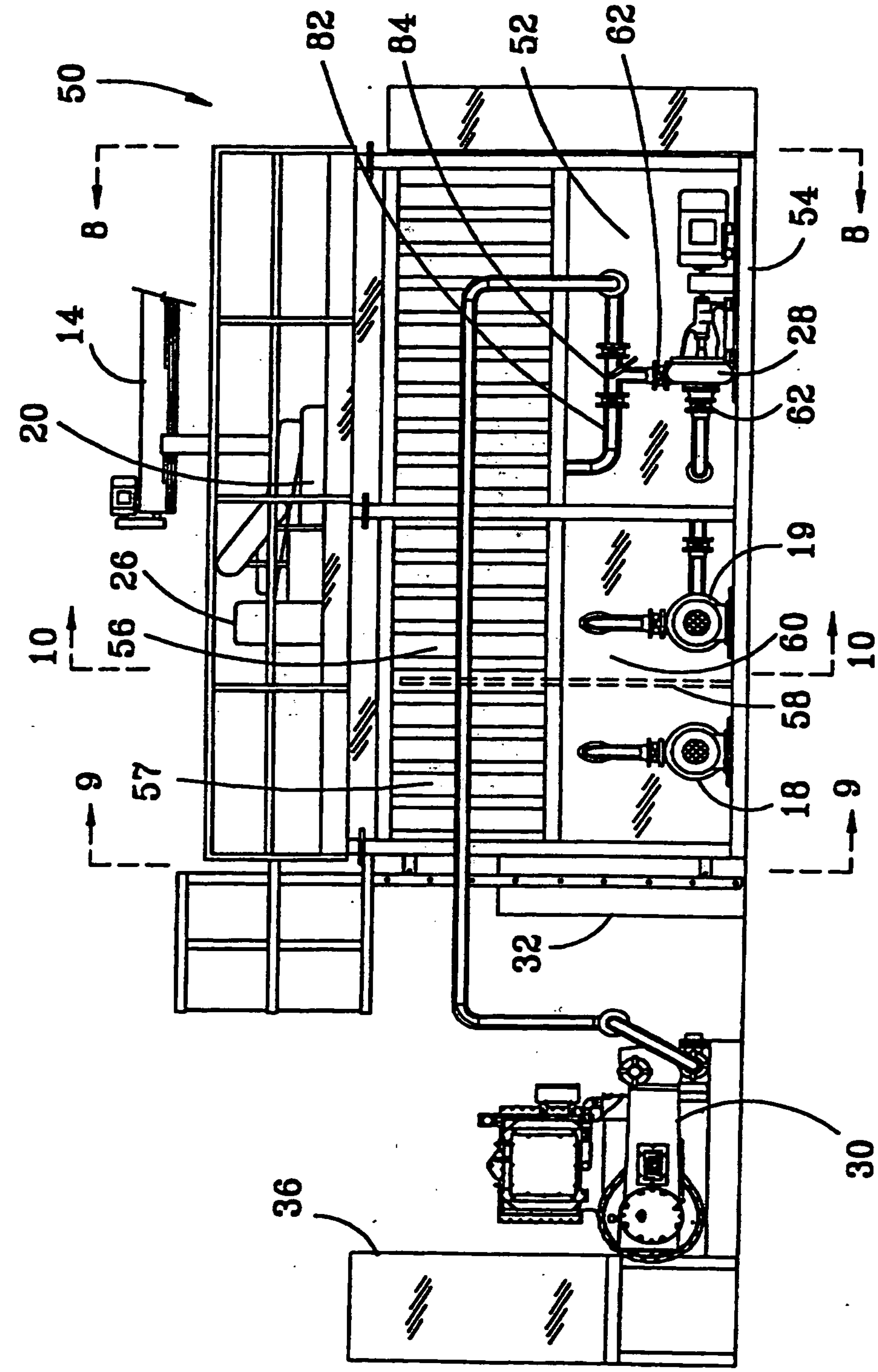

FIG. 6

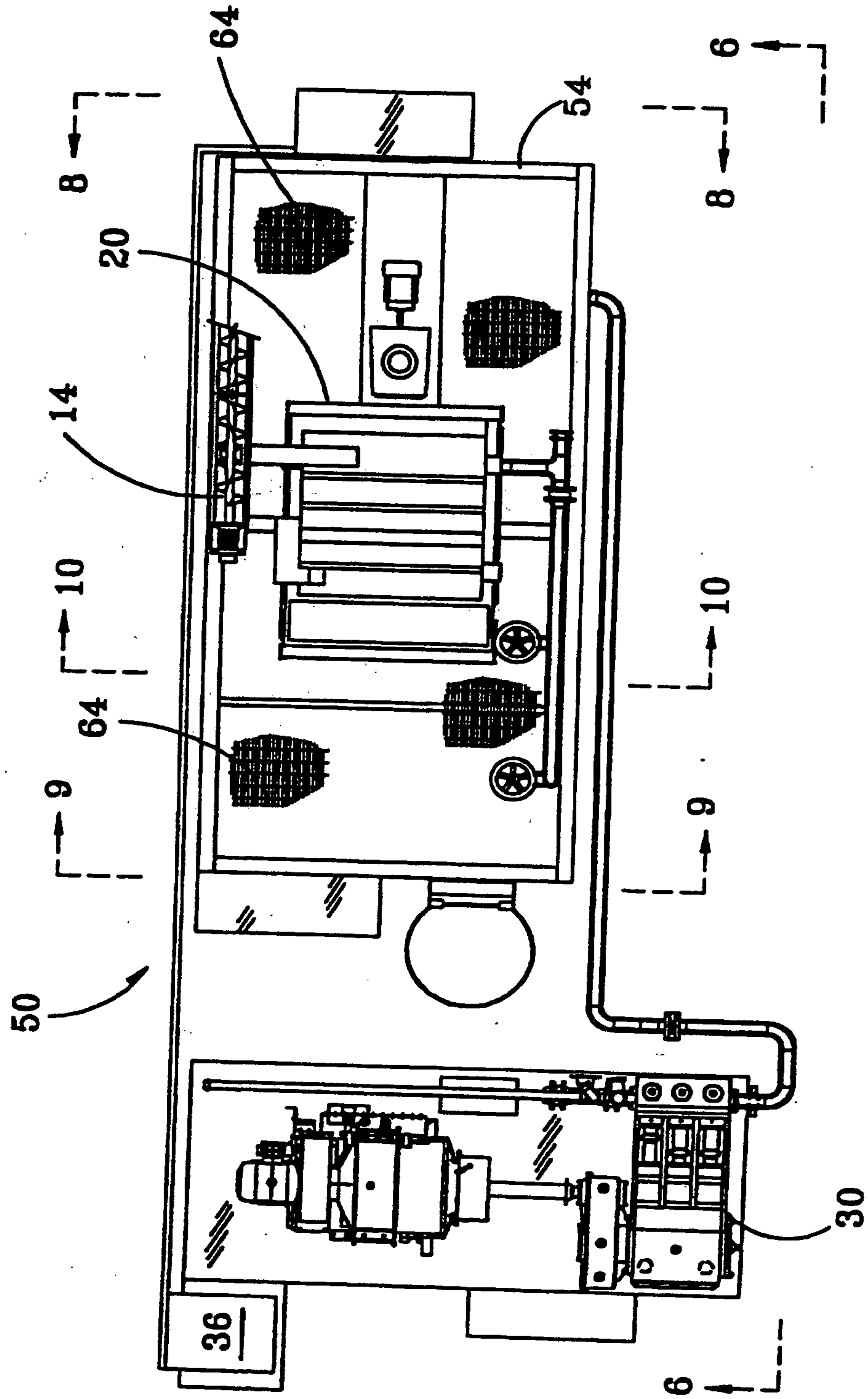

FIG. 7

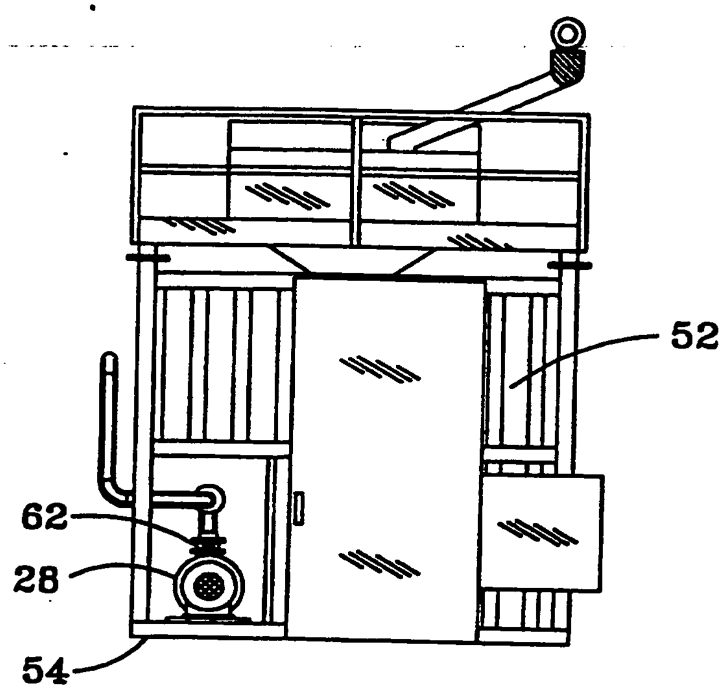

FIG. 8

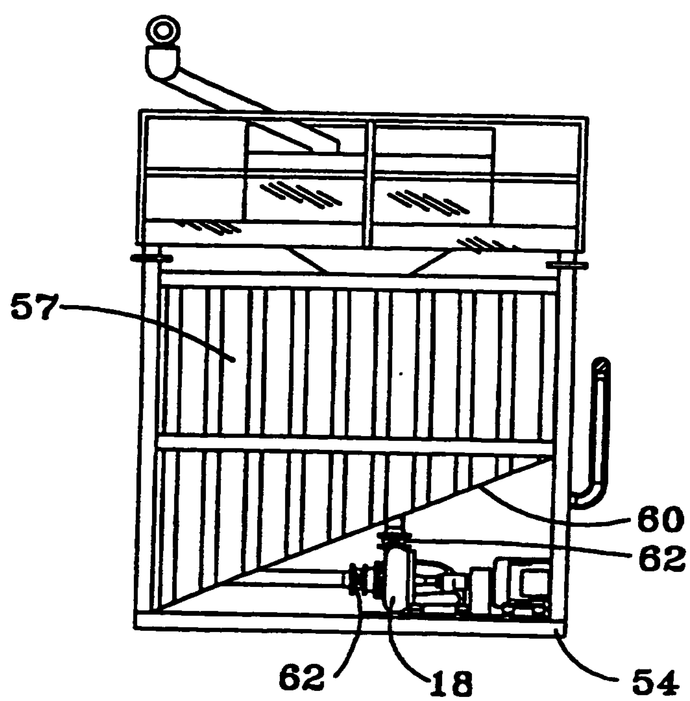

FIG. 9

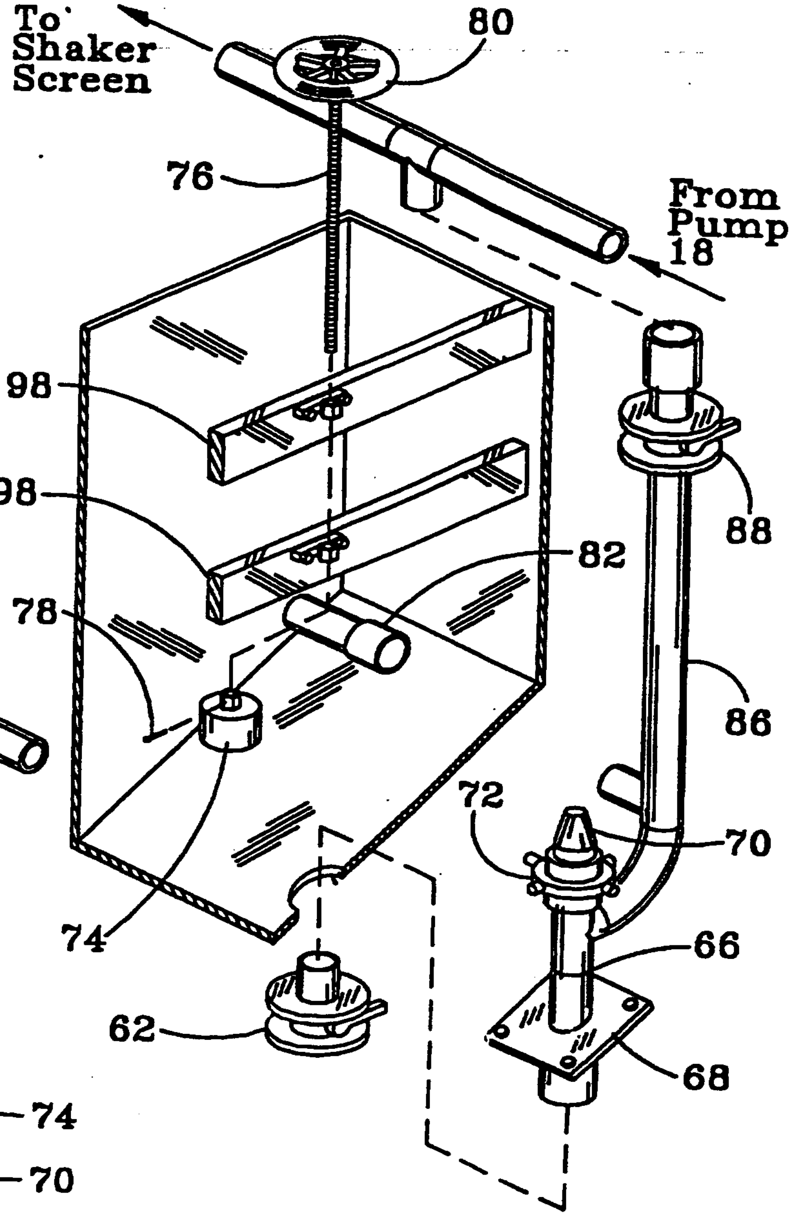
To Shaker Screen
80
76
From Pump 18
98
98
82
78
88
86
72
70
74
66
62
68

FIG. 11

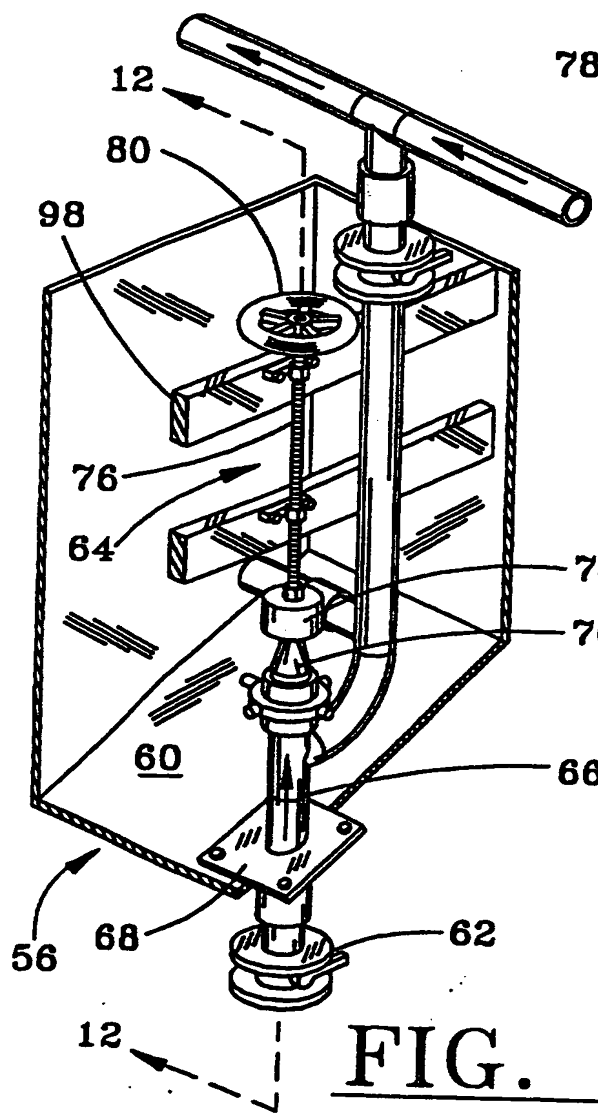
12
80
98
76
64
74
70
60
66
56
68
62
12

FIG. 10

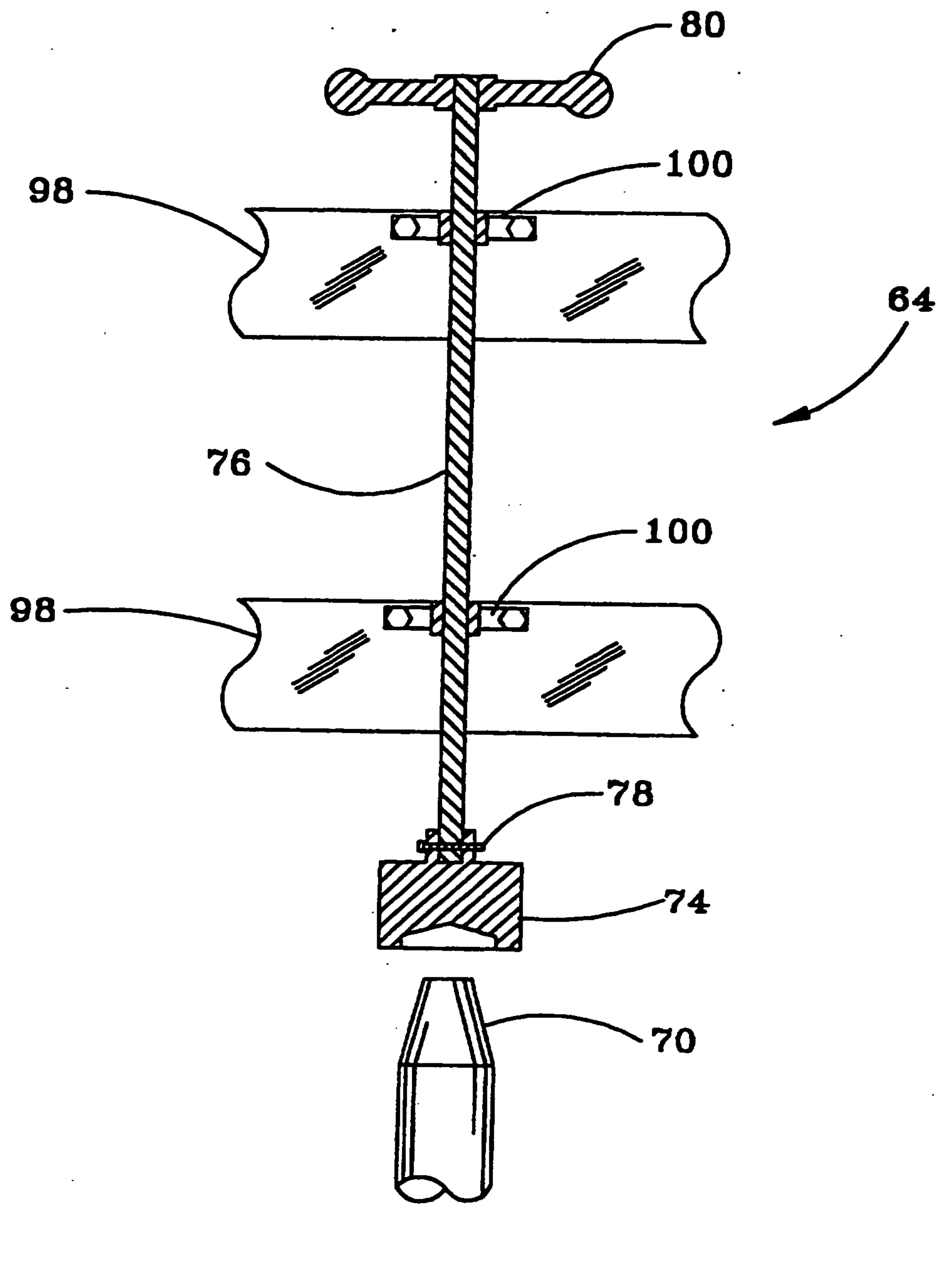

FIG. 12

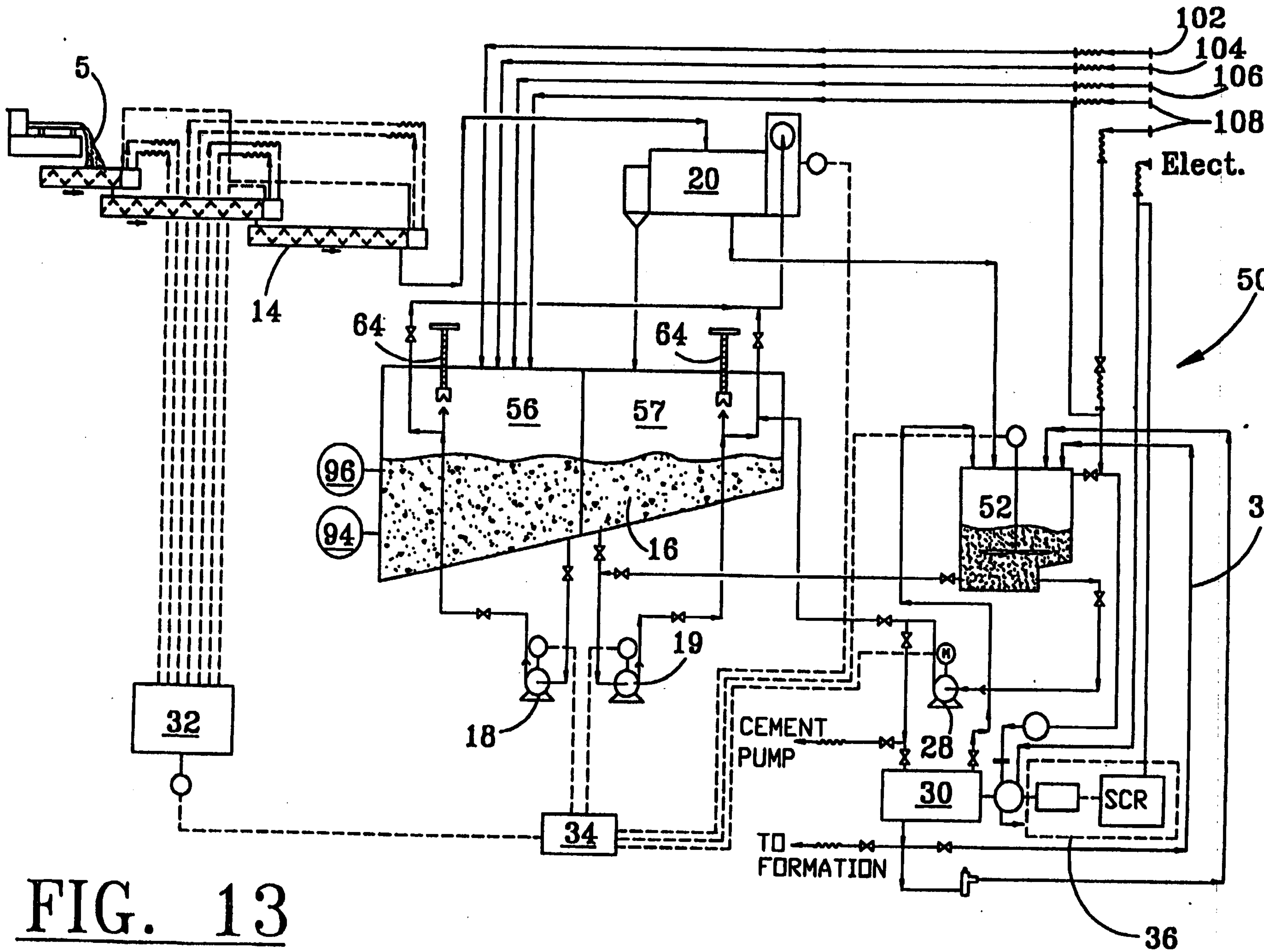
5
14
102
104
106
108
Elect.
20
50
64
64
56
57
96
94
16
52
38
18
19
CEMENT PUMP
28
30
SCR
TO FORMATION
32
34
36

FIG. 13

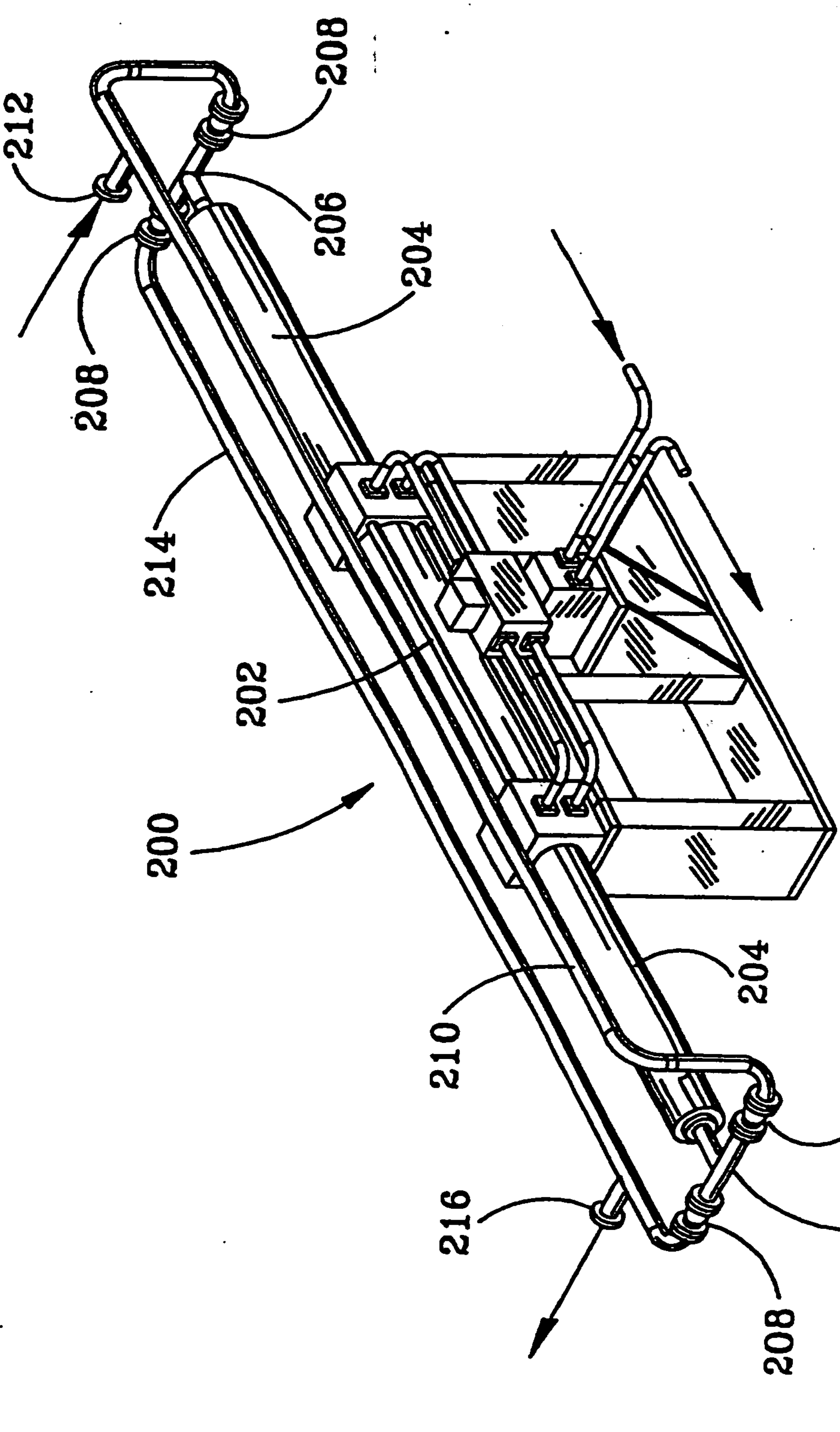

FIG. 14

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APPLICATION FOR PATENT

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INVENTION: Cuttings Injection System

SPECIFICATION

BACKGROUND OF THE INVENTION

1. FIELD OF THE INVENTION

This invention relates to the collection and processing of drill cuttings separated from a drilling rig's solids control system and more particular to the processing and injections of such cuttings into fractures in the earth formation adjacent the well being drilled via the annulus between a well casing and well bore or into other such cuttings disposal scenarios.

2. GENERAL BACKGROUND

In the oil and gas drilling industry the processing of drill cuttings and their disposal has been a logistics and environmental problem for a number of years. Various systems have been developed for handling and processing the cuttings for disposal and reclamation. Such systems include returning the cuttings via injection under high pressure back into the earth formation in a manner such as that described in U.S. Patent 4,942,929, 5,129,469 and 5,109,933, and the treatment of drill cuttings as disclosed by U.S. Patents 4,595,422 5,129,468, 5,361,998 and 5,303,786 . However, in practice, the injection process is not as simple as it may seem. The preparation of the cuttings into a homogeneous mix which is acceptable to high pressure pumps used in pumping material down a well is essential.

Transforming the cuttings into a pumpable slurry is complicated by variable drill rates producing large volumes of cuttings at times thereby creating surges in drill waste materials, the need to pump the slurry at high pressures into the earth and/or formation fractures hundreds if not thousands of feet below the surface. Complications also arise due to the need for constant velocity and high horsepower while pumping. On offshore platforms space is at a premium. Therefore, cuttings treatment units must be compact and as light in weight as possible. Solids control equipment is most often placed in hazardous areas, near the well bore, where large horsepower internal combustion engines are not permitted due to the possibility of high gas concentration. Therefore, any additional equipment used for processing solids must meet stringent explosion proof requirements for such areas of the rig.

Heretofore, cuttings injection has not gained wide acceptance in offshore drilling operations such as may be found in the North Sea, primarily due to the problems discussed above and the inefficiency and ineffectiveness of the cuttings preparation and injection processes.

Although, other cuttings processing system have been developed for preparing drill cutting for disposal and some have been tried in an attempt to inject such processed drill cuttings into a well bore, as is disclosed by U.S. patents 4,942,929, 5,129,469, and 5,109,933 and 5,431,236. However, none combine, individually or collectively all of the advanced features, required for problem-free cuttings injection, disclosed herein by the instant invention.

The problems associated with cuttings injection are numerous as expressed by Warren in U.S. Patent 5,431,236. Starting with processing of the cuttings for injection, we find that the particles are not uniform in size and density making the slurification process very complicated. The cuttings mixture often plugs circulating pumps, the abrasiveness of the

cuttings also abrade the pump impellers causing cracking, some attempts have been made to use the circulating pumps for grinding the injection particles by purposely causing pump cavitaion, thereby shortening pump life, hard cakes build up in tanks creating circulation problems and circulation pumps cavitate unexpectedly due to irregular particle size. Therefore, it is known that a uniform particle size of less than 100 micron must be maintained for proper formation injection at the well site. Maintaining such consistency with hard and soft materials is very difficult. The use of shear guns to reduce particle size as taught by Warren does not insure consistency and requires continuous recalibration thereby reducing the volume capacity of the processor. Warren also teaches that sand should be separated through the use of hydrocyclones which further reduces throughput volume.

Next we find that since no two earth formations are alike it is very difficult to prevent plugging of the formation fractures in the well bore especially when there are long delays in placement of the injection slurry in the formation. Plugging of the formation fractures often occurs as a direct result of large particle size, often in the range of 300 micron or greater, combined with high pressure high volume applications. Plugging of the well formation results in extensive well drilling downtime which is very expensive.

Cuttings injection failures have occurred primarily due to the inability to, handle large volumes of cuttings surges, fine tune the injection process by providing particle size control, uniform slurry density and to provide volume and pressure control over the injection process. Further, attempts to inject cutting slurries into the earth have met with failure as a result of the inability to manually control all facets of the process and injection operation. As a result of such failures most offshore drilling operators in the North Sea have ban the practice and have resorted to using expensive synthetic drill fluids.

It is to this end that the present invention has been developed, the proprietary know-how of which has been maintained until disclosed herein thereby, disclosing a unique efficient system and method for injecting drill cuttings into an offshore oil and gas well in a drilling environment requiring compactness, relatively light weight, low maintenance, full automation and operability in hazardous potentially explosive environments.

SUMMARY OF THE INVENTION

The instant invention has overcome the problems of the prior art and has proven itself by successfully performing cuttings processing and injection in wells where others have failed under identical conditions. The instant invention relates to a drill cuttings processing and injection system for use in hazardous oil and gas well drilling environments where compactness, smooth high performance injection pumping which provides zero downtime and volume variability, and where reduced maintenance are essential. In accordance, a modular processing system is provided comprising a shaker package, a grinder and/or roll mill package, a slurrification control package, Slurrification tanks, transfer pump package, injection pump package, air control system , hydraulics package, and Electrical package. The self-contained system transfers drill cuttings from the drilling rig's cuttings shaker discharge trough to the system slurrification package where the cuttings are further processed for injection, via a high pressure pump, deep into the earth's formation. These and other aspects of the present invention together with certain advantages and superior features thereof may be further appreciated by those skilled in the art upon reading the following detailed description.

BRIEF DESCRIPTION OF THE DRAWINGS

For a further understanding of the nature and objects of the present invention, reference should be made to the following detailed description taken in conjunction with the accompanying drawings, in which, like parts are given like reference numerals, and wherein:-

FIG.1 is a side elevation of the process module;

FIG.2 is top view of the process module;

FIG.3 is schematic diagram of the process system;

FIG.4 is a cross section view of the holding tank particle fragmentation system;

FIG.5 is a cross section view of the flow path of the cutting slurry into the earth formation via a well bore annulus;

FIG. 6 is a front elevation of a second embodiment of the cuttings and injection module;

FIG. 7 is a top view of the second embodiment illustrated in Fig. 6;

FIG. 8 is a right side view of the embodiment illustrated in Fig. 6;

FIG. 9 is a left side view of the embodiment illustrated in Fig. 6 taken along sight line 9-9;

FIG. 10 is a partial section view of the embodiment illustrated in Fig. 6 taken along sight lines 10-10;

FIG. 11 is a partial exploded view of the arrangement shown in Fig. 10;

FIG. 12 is a cross section view taken along the sight line 8-8 in Fig. 10;

FIG. 13 is schematic diagram of the process system of the second embodiment illustrated in Fig's 6-9; and

FIG. 14 is an isometric view of an alternative injection pump.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENT

Turning first to **Fig.1** and **Fig. 2** we see the invention **10** comprises a processing module **12** which, when assembled, is self contained and fully operational for operation on an offshore drilling location. The Module **12** system as best seen in **Fig. 3** further comprises an in-feed cuttings conveyor **14** or other such means which feed overflow drill cuttings **5** from a drilling rig's drilling fluid mud recovery system's shell shakers to the process module **12** where the cuttings **5** are deposited into a first slurry tank **16**. The tanks are configured with special baffles and a conical lower portion to prevent plugging and caking of the solids and increase the speed in which the cuttings in a slurry are feed to the grinder pumps **18,19**. The cuttings slurry **15** is agitated and ground by the centrifugal shredding or the grinding pumps **18, 19** located adjacent the slurry tank **16** where water is added as necessary to provide a pumpable slurry solution. The slurry **15** is then pumped via either of the two grinding pumps **18,19** to a system shale shaker **20** where the slurry **15** passing through the shale shaker's screens is fed to a second slurry tank **22**, where it is further agitated and mixed, or to a holding tank **24**. Overflow entrained cuttings which do not pass through the shale shaker's **20** screens is gravity fed to a roll mill **26** where the oversize cuttings **5** such as sand, limestone and shale are instantaneously ground into fine particles and fed back to the first and second slurry tanks **16,22**. This high speed milling operation performed by roll mill **26** serves to significantly reduce particle size to a uniform consistence, thus reducing the possibility of restricted flow rates caused by irregular size particles entrained in the slurry during the cutting's **15** first pass through the slurry tanks **16,22**. A third pump **28** is provided for recirculating slurry **15** between the holding tank **24** and the two slurry tanks **16,22**. The second circulating pump **19** also serves as backup for the first grinding pump **18** thus allowing either of the slurry tanks **16,22** to be the primary tank. Pumps **18** and **19** are fitted with special oversize impellers having large tungsten carbide particle impregnated matrix coatings to prevent cracking and wear. These large impellers shred the cuttings **5** in a manner whereby the softer cuttings are degraded and become entrained in the slurry immediately. Cavitation

of the pumps **18,19** is purposely avoided thus reducing wear and cracking of impeller blades. Connection lines are provided for feeding the homogenous slurry, resulting from thorough mixing and slurry particle reduction, to a high pressure injection pump **30** for injection into the annulus **44** of a well bore **46** and ultimately into the earth formation **48** as seen in **Fig. 5** or to cement pumping operations if needed. A hydraulics package **32** is provide for driving conveyor motors and an electrical control package **34** is provided for operations of all AC operated equipment. i.e. agitation motors, pump motors, sensors, etc.

A special electrical AC/DC "**Speed Control Regulator**" (SCR) package **36** is provided for controlling the large, electrical motor driving the high pressure triplex or piston type injector pump **30**. This type of motor control has been widely used for industrial plant systems for many years. However, SCR systems have not been employed in the offshore oil and gas industry for drill cuttings **5** injection use in Hazardous locations. It has been found that due to its complexity, its maximum horsepower and speed limitations and its ability to meet class **1 zone 1** hazardous location requirements SCR drives are ideal for such applications. Such zone classifications are used in the industry to designate potentially hazardous gas locations which could become flammable. Hazardous locations are generally limited to equipment having heavy gas-tight enclosures for all electrical apparatus. Therefore, in this case zone 1 on an oil or gas well drilling platform is considered more hazardous than zone two due to its closer proximity to the well head (generally within 50 feet) would require a much higher safety factor with regard to the equipment's probability of causing sparks which could ignite gases emitted from the well.

Problems with such drives in the past have more recently been overcome with the more common use of solid-state circuitry and computer logic systems making such systems less complicated and maintenance free. The SCR system **36** is ideally suited to this particular operation due to its ability to control a wide range of motor speeds, adjustable torque control, excellent speed regulation, dynamic

braking, fast, stable response to changing load conditions encountered in deep well pumping operations, horsepower limiting, pressure limiting on well cuttings injection, high efficiency and automatic operation.

A very high horsepower drive, in the 1000 horsepower range, is required for driving the high volume injection pump 30. The injection pump 30 has a discharge pressure of up to 15000 PSI. Several types of injection pumps may be used including triplex and large displacement piston pumps. The prior art usually utilizes a large direct drive diesel engine located in zone 2 (semi-hazardous area) or an inefficient hydraulic drive motor powered by a remote engine or an explosion proof electric motor and pump package as a drive means approved for location in zone 1 areas. However, hydraulic drives have proven to be incapable of controlling high pressure injection pumps of this magnitude (over 200 horsepower) in a satisfactory manner. Primarily due to their high maintenance, heat, inefficiency and noise levels. Noise levels being restricted to 80 decibels or less on offshore drilling rigs in the North Sea increases the difficulty of their use.

The instant invention utilizes a direct coupled electric motor drive for the injection pump 30 controlled by the Speed Control Regulation system 36. The Speed Control Regulation (SCR) system 36 allows an explosion proof motor to be close coupled to a high pressure injection pump. The SCR system is then controlled electrically by a programmed computer system. Thereby providing small foot print, light weight, constant or variable horsepower and torque at selected operating speeds thus reducing surging and stalling of the cuttings injection pump process. There are several methods which may be used to provide speed control for drive motors coupled to the triplex injection pump. For example an engine driving a DC generator which in turn drives a DC driving motor having speed control capability. A second options may be the use of an AC motor driving the DC generator, an AC frequency controlled motor drive, or an AC motor with SCR capability. In any

case the advantages of an electric speed controlled drive system far exceeds that of a hydraulic pump and motor drive.

Automated electrical speed control and pressure controls allow other control systems to be implemented which are computerized to assist in automating and controlling the injection process system. Therefore, it is possible to fully automate the process based on formation reaction information. Such a system has many advantages, for example, automation of the system's injector pump speed and torque also prevents formation plugging and is interlocked to protect the well from over pressurization. The systems may also be run at very low speed and low pressure thereby preventing large formation fractures. However, when the need arises high pressure and high horsepower can be applied to fracture the formation.

It is also important to have the ability to leave the slurry in the formation for long periods without plugging the formation or the casing annulus. Therefore, a process has been developed and included into the system for automatically injecting premixed gels having yield strength and fluid loss properties into the slurry solution thereby allowing for formation sensitivity. Such automatic injection may be programmed to a predetermined rate based on formation requirements or to meet real time changing conditions.

Automation further allows computer control of multiple processes thereby drastically reducing or eliminating the need for excessive manning of the system on a constant basis, thus reducing cost of operation.

It is highly desirable to reduce the entrained particle size to less than 100 micron in order to insure long term success of cuttings injection and significantly increase the cuttings volume a well will receive. The smaller the particles size the less plugging and fracturing occurs in the earth formation. Therefore, an important feature of the injection process module 12 is its ability to size and fragment cuttings particles suspended in the slurry 15 at high speed and pressure and thereby preventing

constipation of the drill cuttings 5 processing system. This feature prevents shutdowns of drilling operations due to cuttings out flow plugging. One aspect of this high speed process includes an impingement system whereby a line 38 is connected to the discharge line of the injection pump 30 is routed to the holding tank where it is divided into two nozzles 40 which are directed onto heavy plates 42. When necessary this line 38 may be charged at high pressure, thus directing discharge flow from the injection pump 30 directly into the holding tank 24 via said nozzles 40. The entrained cuttings then strike the heavy plates 42 at high velocity thus fragmenting such particles making the slurry even more homogeneous. This system further serves to hydrate the introduced gel chemicals and enhance the fluidity of the drill cuttings 5 thus aiding in slurry preparation and to provide cuttings slurry 15 quality control.

The second embodiment 50 as illustrated in **Fig. 6** perform the essentially the same function as the first embodiment 10. However, this arrangement provides a more compact and efficient unit. For example the holding tank 24 and the two slurry tanks 16 and 22 have been unitized. As seen in **Fig. 6** the holding tank 52 occupies one end of the skid 54. A lower portion of the holding tank 52 is removed, as seen in **Fig. 8** to provide a space for the super charging and recirculating pump 28. The two slurry tanks 56,57 occupy the remaining portion of the skid 54 adjacent the holding tank 52 separated only by a petition 58. The slurry tanks 56.57 have sloping bottoms 60 , as seen in **Fig. 9**, extending the width of the skid 54. This allows room to mount the grinding pumps 18, 19 below the tanks. This arrangement allow the width and the height of the skid 54 to be kept to a minimum while maintaining maximum capacity. Thereby producing a smaller foot print where space is at a premium. To improve service ability, quick couples 62 are provided on all pump connections thus allowing fast pump clean out and/or replacement. As seen in **Fig. 7** the shaker 20 is mounted above the holding and slurry tanks 52,56-57 which allows for easy access and visual inspection of the tank interiors via screen decks 64. Turning now to **Fig. 10** we see a somewhat different

arrangement of the particle size control apparatus which takes the place of the high pressure impingement system illustrated in **Fig. 4** of the first embodiment **10.** This embodiment **50** utilizes the grinder pumps **18** and **19** to direct the slurry **16** upwards through a stand pipe **66** which is removable by disconnecting the deck plate **68** and uncoupling the quick couple **62** . the stand pipe is coupled to a replaceable nozzle **70** via a pipe union **72.** The slurry **16** is then directed towards a replaceable impingement member **74** having a conical portion therein which is in turn connected via threaded rod **76** and pin **78.** The impingement member may therefore be adjustably lowered into close proximity with the nozzle **70** by simply turning the hand wheel **80** connected to the threaded rod **76,** thus adjusting the particle size of the slurry **16.** As seen in **Fig. 11** this arrangement not only allows the slurry **15** particle size to be adjusted from the top of the tanks **56,57** but also allows quick removal for cleaning or replacement of the stand pipes **66,** nozzle **70** and impingement member **74** from the top of the tanks **56,57.** As seen in **Fig. 12** the threaded rod **76** is supported by removable, threaded nut, assemblies **100** mounted to frame members **98.**

It should also be noted that by having the slurry tanks **56,57** located adjacent the holding tank **52** separated only by a common partition which is slightly below the level of the surrounding walls thereby allowing the slurry **16** in the holding tank to overflow into the slurry tanks **56.57** if necessary.

As seen in **Fig. 6** piping **82** leading from the outlet of the super charging pump **28** may be directed via a valve **84** to the stand pipe **66** located in the first slurry tank **56** , thereby further reducing the particle size of the slurry in the holding tank. Piping **86** is also provided in each of the slurry tanks as seen in **Fig. 11** which directs flow of the slurry from the grinding pumps **18,19** back to the vibrator screen **20** via valve **88** where the cuttings were first delivered via a transfer system **14** for separation. The shaker or vibrator screen **20** delivers all fluids and particles of a predetermined size passing through the screen as underflow directly to the holding tank, while the oversize cuttings

materials are discharged as overflow into the cuttings slurry tanks **56,57** for processing by the grinding pumps **18,19** and the particle quality assurance system controlled by the impingement and recirculating system discussed above.

As seen in **Fig. 13** the second embodiment further includes both temperature sensors **96** and viscosity and density sensors **94** located in each of the slurry tanks and controllers for same. It is also anticipated that chemicals used for controlling the viscosity of the slurry **16** may be piped via line **102** into each of the slurry tanks **56,57** as well as waste water **104** and sea water **106** or fresh water to control the density.

As previously explained herein the injection pump 30 may be replaced by a piston or cylinder intensifier pump such as that illustrated in Fig. 14. This type of pump 200 utilizes a double acting hydraulic cylinder assembly 202 having dual rods one extending from each end of the piston thereby forming a double rod cylinder. Each rod is then enclosed or encased in a product cylinder 204 having inside diameter slightly larger than the rod diameter. Thereby intensifying the force of the cylinder rod by the difference between the hydraulic cylinder piston displacement and rod displacement multiplied by the hydraulic pressure. Each product cylinder 204 is fitted with a pipe tee fitting 206 at one end whereby a check valve 208 is attached to the each of the two remaining ends. An inlet manifold line 210 is connected to one of the check valves 208 at each product cylinder 204 in a manner whereby the manifold line 210 is also connectable via a quick coupling 212 to the drill cuttings tank. An outlet manifold line 214 is also connected to the remaining check valve 208 at each product cylinder 204 in a manner whereby the manifold line 214 is also connectable via quick coupling 216 to the well head injection line. The hydraulic cylinder 202 is connected to a hydraulic power unit and valve system having electric sensors and controls which alternately stroke the cylinder 202. The linear configuration of the pump unit 200 allows the unit to fit snugly within the confines of the skid package of the units 12 and 50 discussed herein.

Because many varying and different embodiments may be made within the scope of the inventive concept herein taught, and because many modification may be made in the embodiments herein detailed in accordance with the descriptive requirement of the law, it is to be understood that the details herein are to be interpreted as illustrative and not in any limiting sense.

WHAT IS CLAIMED IS:

1. A modular processing and injection system for the injection of drill cuttings, in an earth formation comprising:

   a) a means for receiving drill cuttings;

   b) a slurry system connected to said means for receiving drill cuttings said slurry system further including a means for producing a drill cuttings slurry and circulating said slurry throughout said processing and injection system;

   c) a means for reducing particle size of said drill cuttings entrained within said slurry;

   d) an injection pump means attached to said processing system, for injecting said drill cuttings slurry into an earth formation;

   e) a drive means for driving said injection pump means;

   f) a speed and torque regulation system connected to said drive means; and

   g) a computer means for electrically controlling said speed and torque regulation, processing, and injection systems.

2. A modular processing and injection system for the injection of drill cuttings, in an earth formation according to claim 1 wherein said means for receiving drill cuttings further includes a collection and conveying system.

3. A modular processing and injection system for the injection of drill cuttings, in an earth formation according to claim 1 wherein said means for reducing particle size of said drill cuttings entrained within said slurry includes a high speed mill.

4. A modular processing and injection system for the injection of drill cuttings, in an earth formation according to claim 1 wherein said means for reducing particle size, of said drill cuttings entrained within said slurry, includes a particle impingement means.

5. A modular processing and injection system for the injection of drill cuttings, in an earth formation comprising:

a) a drill cutting collection and conveying system connected to a drilling rig's solids control shale shaker system;

b) a slurry system connected to said collecting and conveying system;

c) a means for producing a cuttings slurry within said slurry system and circulating said slurry throughout said processing and injection system;

d) a milling means for reducing particle size of said drill cuttings entrained within said slurry;

e) an injection pump means attached to said processing system, for injecting said drill cuttings slurry into an earth formation;

f) a drive means for driving said injection pump means;

g) a speed and torque regulation system connected to said drive means; and

h) a computer means for electrically controlling said speed and torque regulation, processing, and injection systems.

6. A modular processing and injection system for the injection of drill cuttings, in an earth formation comprising:

a) a drill cutting collection and conveying system connected to a drilling rig's solids control shale shaker system;

b) a slurry system connected to said collecting and conveying system;

c) a means for producing a cuttings slurry within said slurry system and circulating said slurry throughout said processing and injection system;

d) a milling means for reducing particle size of said drill cuttings entrained within said slurry;

e) a means of impinging said drill cuttings entrained within said slurry for further reducing said particle size;

f) an injection pump means attached to said processing system, for reinjecting said drill cuttings slurry into an earth formation;

g) a drive means for driving said injection pump means;

h) a speed and torque regulation system connected to said drive means; and

i) a computer means for electrically controlling said speed and torque regulation, processing, and injection systems.

7. A modular processing and injection system for the injection of drill cuttings, in an earth formation according to claim 1 wherein said means for circulating said slurry is a pump having an impeller coated with a tungsten carbide impregnated matrix.

8. A modular processing and injection system for the injection of drill cuttings, in an earth formation according to claim 6 wherein said means of impinging comprised a high pressure slurry line connected to said injection pump terminating inside a tank, said high pressure line having at least one nozzle inside said tank directed towards an impingement plate.

9. A modular processing and injection system for the injection of drill cuttings, in an earth formation according to claim 6 wherein said milling means is a roll mill.

10. A modular processing and injection system for the injection of drill cuttings, in an earth formation according to claim 1 wherein said injection pump is a high pressure triplex type pump.

11. A modular processing and injection system for the injection of drill cuttings, in an earth formation according to claim 1 wherein said computer means includes a program for automating said processing and injection system's functions in response to well formation injection variables.

12. A modular processing and injection system for the injection of drill cuttings, in an earth formation according to claim 1 wherein said speed and torque control regulation system comprises an electronic, programable motor speed controller with torque sensing feed back and horse power limiting circuitry.

13. An oil and gas well, drill cuttings, processing and injection system comprising:

a) a conveying means for collecting and delivering cuttings via fluid recovery shale shakers to said processing and injection system;

b) at least one slurry tank connected to said conveying means;

c) a means located within said slurry tank for mixing a fluid with said cuttings to produce a slurry;

d) a means for circulating said slurry;

e) a system shale shaker fludically connected to said means for circulating said slurry;

f) a means for grinding cuttings particles entrained in said slurry and discharging said slurry into slurry tank;

g) a holding tank fluidically connected to said system shale shaker, said means for circulating and said second slurry tank;

h) a pump means for circulating said slurry from said system shale shaker fludically connected to said holding tank and said second slurry tank;

i) an injection pump means fludically connected to said first and second slurry tanks and said holding tank for injecting processed cuttings in said slurry into an earth formation;

j) an electrical drive means for driving said injection pump means;

k) a means for controlling speed and torque of said electrical drive means; and

l) a fragmentation means located inside said holding tank for fragmenting entrained particles in said slurry.

14. An oil and gas well, drill cuttings process and injection system according to claim 13 wherein said fragmentation means comprises a plurality of nozzles attached to an inflow line from said injection pump discharge, said nozzles being further directed towards a metal surface plate.

15. An oil and gas well, drill cuttings process and injection system according to claim 13 wherein said drive means is an electric motor having electric speed control regulation with torque and horsepower limiting capability.

16. An oil and gas well, drill cuttings process and injection system according to claim 13 wherein said electrical control means for controlling speed and torque of said electrical drive means are

contained in housings which meet electrical safety regulations for class 1 zone 1 hazardous locations.

17. An oil and gas well, drill cuttings process and injection module according to claim 13 wherein said injection pump means is a high pressure triplex pump.

18. An oil and gas well, drill cuttings process and injection system according to claim 13 wherein said electrical drive means is an electric motor having between 200-1000 horsepower.

19. A method of processing and injecting drill cuttings into an earth formation adjacent a well casing while drilling comprising the steps of.

a) collecting drill cuttings from shale shakers associated with a drilling mud recovery system;

b) processing said drill cuttings by passing said cuttings through an injection module comprising;

i) a conveying means for delivering said drill cuttings to said injection module;

ii) a first slurry tank connected to said conveying means;

iii) a second slurry tank connected to said first slurry tank;

iv) a means located within said first and second slurry tanks for mixing a fluid with said cuttings to produce a slurry;

v) a means for circulating said slurry between said first and second slurry tanks;

vi) a system shaker screen connected to said means for circulating said slurry;

vii) a means for high speed grinding and discharging entrained cuttings into said first and second slurry tanks;

viii) a holding tank fluidically connected to said shaker screen, said means for circulating and said second slurry tank;

ix) a means for circulating said slurry from said shaker screen connected to said holding tank and said second slurry tank;

x) an injection pump means fludically connected to said first and second slurry tanks and said holding tank for injecting said slurry into an earth formation;

xi) an electrical drive means for driving said injection pump means;

xii) a means for controlling speed of said electrical drive means; and

xiii) a fragmentation means located inside said holding tank for fragmenting entrained particles in said slurry.

c) controlling quality of said slurry by fragmenting entrained particles in said slurry;

d) injecting said drill cuttings into an earth formation; and

e) controlling speed, and torque of said injection pump, electrically.

20. A method of processing and injecting drill cuttings according to claim 19 wherein said fragmenting process of said entrained particles is accomplished by impinging said entrained particles, at high pressure, against a set of plates.

21. A method of processing and injecting drill according to claim 19 wherein said means for controlling said electrical drive means includes electronically sensing torque requirements and varying the drive speed to compensate and maintain a preselected pressure on said cuttings slurry during injection.

22. A method for processing drill cuttings for injection into an earth formation comprising the steps of:

a) collecting said drill cuttings;

b) producing a slurry by adding fluid to said drill cuttings;

c) sizing by milling said drill cutting slurry;

d) homogenizing by mixing and circulating said slurry until all solid particles are entrained in solution; and

e) fragmenting said entrained solid particles by impinging said solid particles at high pressure, against a surface.

23. A method for processing drill cuttings for injection into an formation according to claim 22 wherein said fragmenting of entrained solid particle reduces said solid particle size to less than 100 micron.

24. A method of processing and injecting drill cuttings into a well formation while drilling comprising the steps of:

a) automating a drill cuttings processing and injection system; and

b) programming said automated processing and injection systems based on real time measurements of down hole earth formation changes.

25. A method of processing and injecting drill cuttings into an earth formation comprising the steps of:

a) automating a drill cuttings processing and injection system; and

b) programming said automated processing and injection systems based on progressive changes in injection system pressure, cuttings density and calculated formation volume capacity.

26. A method of processing and injecting drill cuttings into an earth formation comprising the steps of:

a) premixing gels and the like for controlling yield strength and fluid loss over long periods in drill cuttings slurry;

b) providing an automated means for introducing said gels into said slurry; and

c) programming said automated means to introduce said gel mix into said slurry at a predetermined rate based on formation requirements.

27. A method of injecting oil and gas well drill cuttings into an earth formation comprising;

a) providing an injection pump;

b) providing an electrical means for driving said injection pump; and

c) providing a means for electrically controlling speed and limiting horsepower of said electrical means for driving said injection pump.

28. A modular cuttings injection system for location on a petroleum drilling rig comprising :

a) means for conveying drill cuttings from said rig to said injection system;

b) a vibrator screen, connected to said means for conveying having overflow and underflow discharge outlets;

c) a modular tank skid comprising a holding tank and at least two slurry tanks fluidly connected to said overflow and underflow outlets;

d) a grinding pump having inlet and outlet ports, connected fluidly to each said slurry tank;

e) a circulating pump having inlet and outlet, connected fluidly to said holding tank;

f) a stand pipe located internal each said slurry tank having a nozzle, said stand pipe connected to said outlet of said grinding pump;

g) a variable impingement member located adjacent said nozzle;

h) an injection pump fluidly connected to said holding tank;

i) an electrical and hydraulic control means for controlling said means for conveying, said grinding pumps , said circulating pump, said vibrator screen and said injection pump.

29. A modular cuttings injection system according to claim 28 wherein said injection system further comprises a system for monitoring and controlling viscosity and density of said drill cuttings.

30. A modular cuttings injection system according to claim 28 wherein said holding tank and said slurry tanks form a single modular unit.

31. A modular cuttings injection system according to claim 28 wherein said drill cuttings slurry in said holding tank is allowed to overflow into said slurry tank .

32. A modular cuttings injection system according to claim 28 wherein said slurry tanks have sloping bottoms.

33. A modular cuttings injection system according to claim 28 wherein said stand pipe is replaceable from the top of said slurry tank.

34. A modular cuttings injection system according to claim 28 wherein said nozzle is replaceable from the top said slurry tank.

35. A modular cuttings injection system according to claim 28 wherein said impingement member further comprises a conical impingement surface and is adjustable relative said nozzle via a hand wheel.

36. A modular cuttings injection system according to claim 28 wherein said system for monitoring and controlling viscosity and density of said drill cuttings includes the use of chemicals, waste and sea water.

37. A modular cuttings injection system according to claim 28 wherein said grinding and circulating pumps are connected to inlet and out conduits via quick couplings.

38. A modular cuttings injection system according to claim 28 wherein said injection pump is a ram injection unit comprising;

a) a hydraulic cylinder having a rod end at each end of said cylinder;

b) a product cylinder connected to each said rod end;

c) a pipe tee fitting connected to one end of said product cylinder, opposite said hydraulic cylinder;

d) an inlet check valve and an outlet check valve connected to said tee;

e) a first manifold having an outlet port connected to each said outlet check valve;

f) a second manifold having an inlet port connected to each said inlet check valve; and

g) a means for automatically alternately stroking said hydraulic cylinder.

39. A modular processing and injection system, for the injection of drill cuttings in an earth formation, substantially as hereinbefore described with reference to the accompanying drawings.

40. A pumping apparatus for use in drill cuttings re-injection comprising a high pressure pump, an electrical drive system directly coupled therewith and a speed controller for regulating the electrical drive system, wherein the speed controller is connected to sensing means and a processor for analysing conditions during a re-injection operation whereby the drive system can be regulated responsive to feedback from said sensing means during the re-injection operation.

41. A pumping apparatus for use in drill cuttings re-injection comprising a high pressure pump, an electrical drive system directly coupled therewith and a speed controller for regulating the electrical drive system, substantially as hereinbefore described with reference to Figures 1 to 13 of the accompanying drawings.

42. A pumping apparatus for use in drill cuttings re-injection comprising a high pressure pump, an electrical drive system directly coupled therewith and a speed controller for regulating the electrical drive system, substantially as hereinbefore described with reference to Figure 14 of the accompanying drawings.

43. A method of processing and injecting drill cuttings into an earth formation, using a regulated electrically driven high pressure injection pump, substantially as hereinbefore described.

The Patent Office

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Databases searched:

UK Patent Office collections, including GB, EP, WO & US patent specifications, in:

UK Cl (Ed.P): E1F: FGM

Int Cl (Ed.6): E21B 21/06, 41/00

Other: Online WPI

Documents considered to be relevant:

Category	Identity of document and relevant passage		Relevant to claims
A	WO 93/20328	(RIG TECHNOLOGY LIMITED)	-
A	WO 92/09380	(DEN NORSKE STATS OLJESESKAP)	-
A	WO 92/09379	(DEN NORSKE STATS OLJESESKAP)	-
A	WO 92/07667	(CAHILL)	-

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